CREAMINKA: An Intelligent Ecosystem for Supporting Management and Information Discovery in Research and Innovation Fields in Universities

Juan Pablo Salgado Guerreo, Daniel Pulla Sánchez,
Jorge Galán Mena, Vladimir Robles Bykbaev,
Verónica Cevallos León Wong and
Adrián Narváez-Pacheco

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.73212

Abstract

This chapter presents a new proposal for supporting the management of research processes in universities and higher education centers. To this aim, the authors have developed a comprehensive ecosystem that implements a knowledge model that addresses three innovative aspects of research: (i) acceleration of knowledge production, (ii) research valorization and (iii) discovery of improbable peers. The ecosystem relies on ontologies and intelligent modules and is able to automatically retrieve information of major scientific databases such as SCOPUS and Science Direct to infer new information. Currently, the system is able to provide guidelines to create improbable research peers as well as automatically generate resilience graphics and reports from more than 17,000 tuples of the ontological database. In this work, the authors describe in detail an important aspect of support systems for research management in higher education: the development and valorization of competences of students collaborating in research process and startUPS of universities. Furthermore, a knowledge model of entrepreneurship (startUPS) as well as an analyzer of general and specific competences based on data mining processes is presented.

Keywords: ontologies, acceleration of knowledge production, higher education, student research competences, entrepreneurship

1. Introduction

Entrepreneurial spirit is an old field, but it is continuously emerging and it attracts the attention of scholars, politicians and professionals in different fields of economics, finance, management and sociology [1]. In the last decades, it has been studied as a driving force for development and a key factor to attain economic growth, the creation of employment and the increase of productivity [2, 3]. Nowadays, the theory of entrepreneurship has extended to new concepts where entrepreneurial spirit is not only known for its business success and benefits, but also for subjective welfare and noneconomic welfare that people can obtain through their skills. Politicians seek to promote entrepreneurial spirit at a macrolevel through education in hopes that a greater understanding will likely create more adept entrepreneurs [4]. In this regard, there is a debate going on related to the academic field if it is really possible to teach students how to be entrepreneurs [5].

Besides creativity and innovation to develop entrepreneurial projects and meet its goals, due to current and fast changes in society, a wide range of skills and competences are needed [6]. In the last few years, higher education institutions at an international level have introduced competences in its educational programs. For example, during the last 5 years, Spain has produced significant advances in the treatment and evaluation of competences, especially in the field of language teaching [7]; Universidad Politecnica de Madrid (UPM) applied the project-based learning (PBL) approach and analyzed the acquisition of regional and global competences by having industrial engineering students complete a course on project management [8]; they even suggested a framework of learning and evaluation based on competences to facilitate the learning of skills in the development of projects [9]; a study to support the skills and competences under the European Union Framework and the Bologna Agreement was also conducted, assisting its evolution through guidance documents that seek to integrate the European systems of higher education and improve employability of European graduates [10].

Regarding tools to analyze competences, there are solutions suggested through the use of questionnaires along with information technologies. In [11], the COMET test is suggested, it was developed by the TVET research group from the University of Bremen and it is based on a model of competence and measurement through open task tests that have a variety of solutions and the evaluation of its results. As part of the TECH project, students from the universities of Seville and Malaga presented the improvement of their competences of collaborative work, efficient use of time, management of online resources and others by carrying out collaborative work in mixed groups on the online learning platform [12]. ComProfits is a project financed by the EU which analyzes the concept of a profile platform of adaptive competences where its main objective is to (i) strengthen the analysis of competences and (ii) improve the quality of staff selection and work performance in the field of IT [13]; another innovative concept for teaching competences with entrepreneurial spirit is open educational practices that work jointly with a StarUp model and seeks to identify the competences that a person has obtained by carrying out the analysis of open educational resources (OER) that have been used through a recommendation system [14]. Another approach applies KIPSSE, which is a self-reporting instrument to be used in the evaluation of competences of projects developed by university students that take part in online learning projects, which tries to identify knowledge integration skills, project skills and self-efficacy based on the results of the qualitative and quantitative analysis of interviews with the project consultants [15].

In this context, the present work presents a computing strategy for the analysis of competences and the networks that an individual (student/entrepreneur/professor) has developed. Such strategy is based on a previous work suggested by Salgado et al. [16] for the evaluation of an individual's competences when developing a project through a trifocal model "auto/hetero/coevaluation." The computing model is made up by an ontology that explains the basis of knowledge of the StartUPS ecosystem and makes it possible to generate inferences, and a schematic and mathematical model to approximate a qualitative and quantitative evaluation of the valuations of the competences applied to the different individuals of the innovation ecosystem.

2. Related work

Among the first studies about an evaluation through competences to individuals and applying computing, there is a debate on how to generate the dissemination of relevant information to users according to knowledge generated within an institution or organization, an aspect highlighted in [17], where it explains that "*one of the challenges of knowledge management is the active and smart dissemination of knowledge to users, without bothering them with information unrelated to their competencies or fields of interest*" and suggests a first approximation of an ontology system based on competences that intend to provide assistance in order to increase productivity of users during their activities according to their profile. In [18], the objective is to design an ontological model, based on the competences of each enterprise, to support decisions at the time of creating collaborative networks within virtual environments called virtual breeding environment (VBE) whose aim is to enhance the competences of employees. A similar case occurs in [19], where manufacturers and distributors need to cooperate and create production networks; therefore, they suggest an approach for the configuration of teams based on profiles by competences applying management of ontologies, management of contexts and elaboration of profiles, and with the aim of identifying the members of the team that are the most suitable to carry out a task.

When it comes to finding a job, developing a project, implementing a business, etc., one of the concerns of employers, investors, and project managers is to identify qualified and committed personnel. How to solve this enigma, and the concern also goes through the educational model, which besides teaching theory, should also assess the performance of students in life by addressing a new approach, through skills or competences as mentioned above. Bodea and Dascălu [20, 21] suggest e-learning as an appropriate activity for the development of competences. Based on the PM competence catalog, which is based on the IPMA competence basis (ICB), they defined an educational ontology for their SinPers e-learning platform, which is structured by a collection of different educational objects (EOs) as elements for the supervision and evaluation of new competences.

As analyzed previously, and as mentioned by Hochmeister and Daxböck [22], "*Competence management systems are increasingly based on ontologies that represent competencies within a given domain*," and as part of the SeCoMine project, they seek to value user competences based on their contribution and social interactions in online communities by developing a user interface for profiles of semantic competences. And regarding work in the field of research, in [23], they suggest the use of the linked open data (LOD) format to describe the competences of researchers, developing the first work flow to generate profiles of semantic users through the analysis of scientific articles by processing natural language, which makes it possible to carry out personalized searches of articles and competent researchers in specific topics.

Regarding competence "measurement" models, there are no generic standards or procedures to evaluate or value, and each proposed model is tailored to a specific context and can be extrapolated to others by making appropriate modifications. As emphasized in [24], for the evaluation of leadership competences under a hypothetical hierarchical scheme, the partial least squares (PLS) trajectory models are used, where to collect information, they use questionnaires that are based mainly on the Likert scale and weightings. Like the previous case, in [25], the procedures and tools used for the evaluation of competences in Erasmus nurse students (ENS) clinics are made up of questionnaires, where each competence is valued in different scale metrics such as Likert. Schelfhout et al. [26] are based on a model of levels where they contemplate domains, subcompetences and scaled behavioral indicators as the basis for giving concrete feedback to students rather than using Likert-scale surveys. Therefore, a mixed study method that combines qualitative and quantitative research techniques (self-assessment/evaluation questionnaires) was used; the evaluation of the validity of this model was done through a confirmatory factorial analysis (CFA).

According to what has been analyzed, formulating an ontological system of the coworking UPS ecosystem and based on that applying metrics to assess the competences of the agents that are actively involved in it are possible and applicable.

3. StartUPS: an entrepreneurship background

The culture of innovation at Universidad Politécnica Salesiana (UPS) seeks to develop a new more complex and formulated concept in [27], which explains that "the university just like a jungle (ecosystem) takes inert and inorganic elements such as knowledge and science to create thriving ecosystems of living organisms whose interactions make up society." This innovative concept seeks to change the educational linearity that governs classrooms toward the productivity of innovation and creativity in spaces or associative groups that share common and multidisciplinary interests (cowork), that break what is conventional, and maintain the center of interest in people, basis of UPS's culture and a primary agent in the interaction and collaboration with diverse talents that seek to transcend social barriers in favor of connectivism [28–30], learning to learn [31–33] and the common good [34].

The ecosystem of innovation at UPS is intended to be something like a free zone, where the flow of ideas, talents and capital can be maximized in a network of collaborative work. The importance of creating places within the institution to encourage this new university culture has been hard and fundamental work in order to "generate" a new educational model based on an individual's life project; therefore, one of the aims of the StartUPS project is that students/professors from the university integrate all the knowledge they have acquired in real-life projects and that they develop behavioral, contextual and technical competences [6] within spaces like the "coworks."

The coworking UPS project is part of UPS's strategy, to become a university of research and innovation, and the culture of entrepreneurship represents a fundamental factor in the achievement of these objectives in the short and long term. In 2015, a series of agreements to integrate the culture of "project work" were adopted in order to develop measures to promote innovation in UPS. This process of change has been accompanied by training for UPS agents (teachers and students) to develop a culture of entrepreneurship and their project management competences. The idea of fostering entrepreneurship from project management competences was aimed at creating an Innovation and Entrepreneurship Ecosystem (coworking StartUPS project). This strategy is part of the implementation processes of Research Groups and Educational Innovation Groups (EIG) at UPS, jointly promoting Research and Educational Innovation, based on the participation of students and teachers who are competent for project management.

As mentioned in [6], "the methodology used within the ecosystem to generate the coworking experience is based on the Working with People (WWP) model, aimed at building dynamics of innovation and learning based on projects"; therefore, the executing and catalytic axis of the entire competence assessment within the coworking StartUPS ecosystem has a project key point. The main idea is to incubate and enhance the abilities of each individual based on the activities that he/she performs within a project or in different proposed events such as: boot camps (RECREATE/RETHOS), mini-boot camps, hackathons, workshops, training courses, research groups and others.

The components discussed in [6] to sustain the ecosystem mention four, a socio-ethical component, a technical-business component, a political-contextual component and an integrating component, which is social learning, oriented to developing a network of entrepreneurship among the university's entrepreneurs, through spaces of learning, discussion and reflection generated in different areas of the university with the participation of faculties and courses. This component is mainly undertaken by the entrepreneurship centers, or coworking spaces, which serve as support to the entrepreneur and allow their interaction. This way they find the physical space of work and the necessary advice so that their ideas and learnings are connected with the national and international market. This connects the UPS entrepreneurship ecosystem with the local, national and international level.

4. Ecosystem approach

The computing model being suggested is part of a more complex system called CREAMINKA, which is a tool designed to support strategic decision-making regarding R + D + i (research + development + innovation) in the university. This component seeks to carry out a specific task, the analysis of competences/skills of the agents that make up this ecosystem by applying the corresponding metrics of these skills through indicators that are valued through a mixed evaluation mechanism.

As shown in **Figure 1**, the structure of the ecosystem is organized in four clearly defined layers: (i) the transactional system for StartUPS, (ii) the microservices component, (iii) the triplet repository and (iv) the mobile/web application. The microservices component is the main layer that supports the entire subsystem; its function is to provide the necessary services so that the flows of information can be matched to the different components. The "StartUPS" transactional system stores information of the agents in the ecosystem, such as data of their competences, projects, evaluation/valuation questionnaires, etc. The triplet repository stores the knowledge model of the innovation ecosystem and previously treated data from the transactional system. The mobile/web application is in charge of the interaction with the different

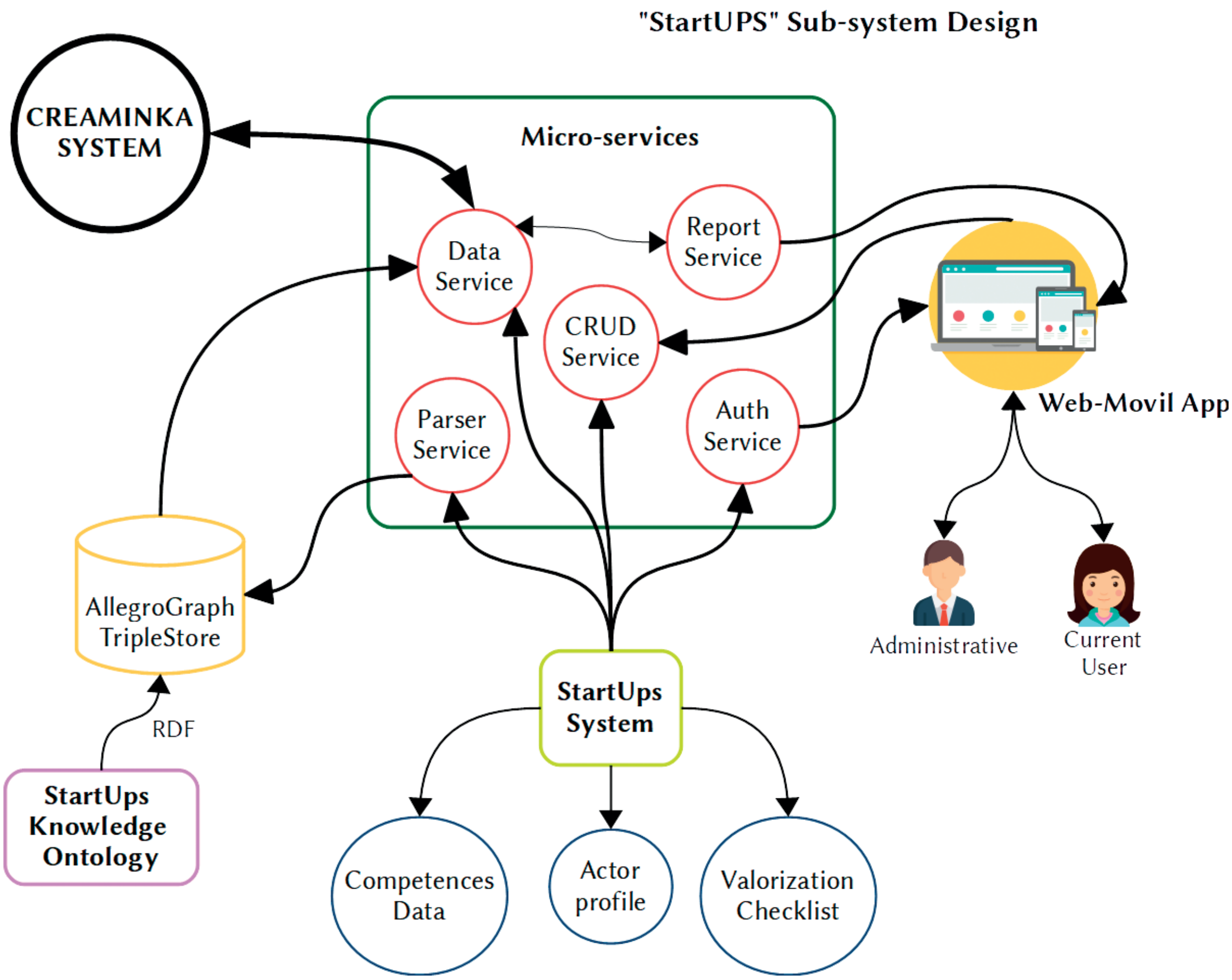

Figure 1. General structure of the StartUPS innovation subsystem.

agents and the mechanism of information input and output. The microservice component has five specific services; the "parser service" microservice, which is responsible for the translation/transformation of data obtained from transactional/nontransactional data sources to data for the ontological model of triplets; the "auth service" microservice has the necessary logic to support the processes of authorization and authentication; the "CRUD service" microservice has the task of creating, reading, updating and deleting information; the "report service" microservice is responsible for creating the different reports using the data provided by the "data service" microservice, which provides all the information processed thanks to different inference mechanisms, mining data and artificial intelligence.

4.1. Competence evaluation model

As mentioned in the related work section, there are several models for the analysis or "measurement" of competences. The suggested model is basically based on four "hierarchical" levels and their weightings relations. The levels are made up by: (i) the general competences (generic) and (ii) the specific competences [35–38], (iii) the indicators and (iv) the trifocal evaluation (auto-hetero-co).

The competence evaluation diagram as illustrated in **Figure 2** starts by carrying out the "trifocal" evaluation of competences of an agent in the ecosystem after having developed a project

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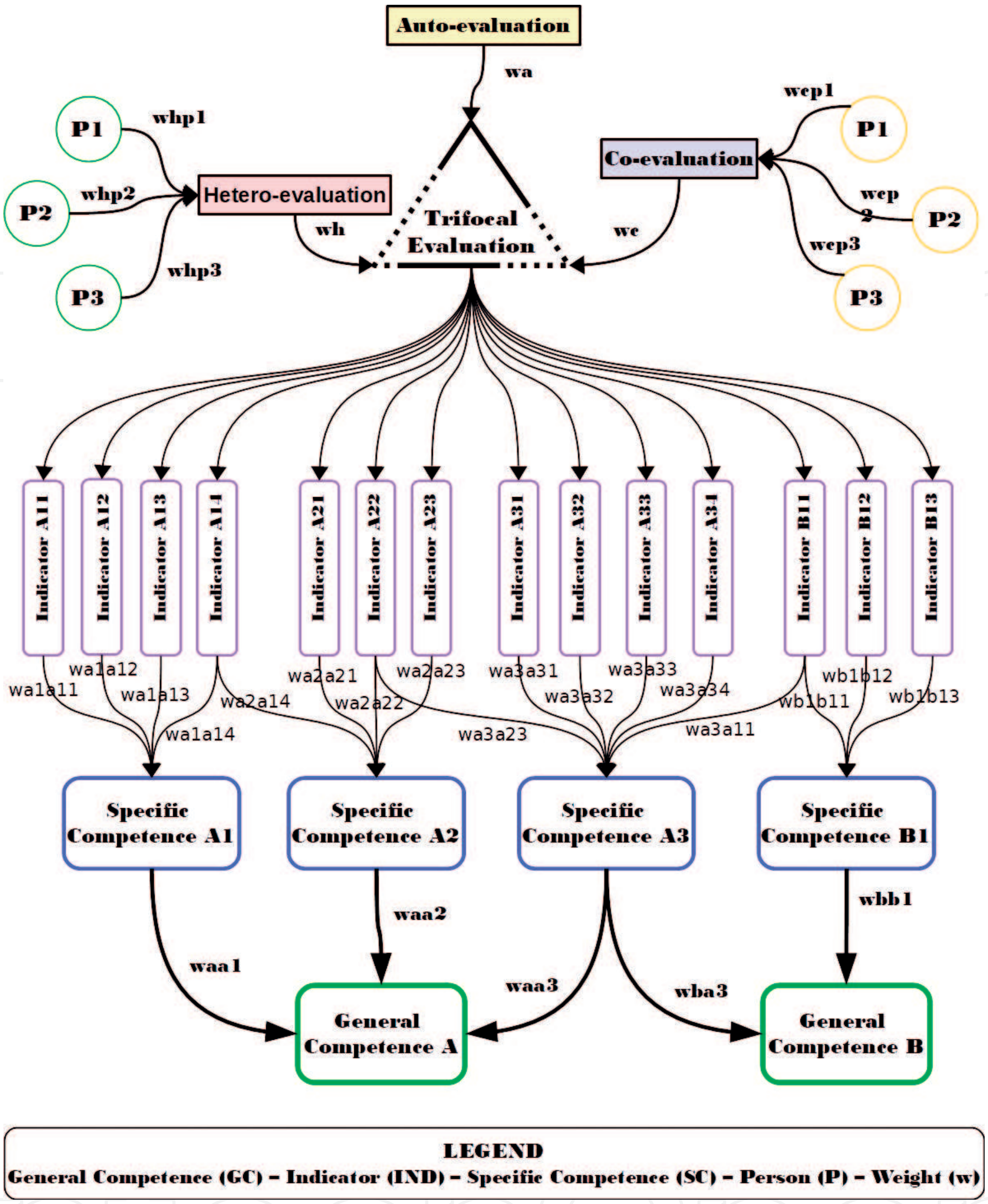

Figure 2. Modular schema of competence evaluation.

or completing a set of activities in an event, training course or workshop within the different innovation spaces created by the university. The evaluation model has two instances, it starts from a qualitative valuation that is subjective toward an attempt of a quantitative valuation that is objective, all this through the use of weights in the relations that exist between the different levels of the competence diagram.

The trifocal evaluation/valuation contains three concepts: (i) heteroevaluation, (ii) coevaluation and (iii) self-evaluation. To begin, there is a questionnaire that contains the battery of indicators to evaluate/value, either for a project or a set of activities; it should be noted that these indicators have already defined a weighting that refers to their specific competence, in addition to having their respective scale of measurement, whether a value scale, Likert scale and others. The heteroevaluation is given by one or more valuators, who also have a weight when completing their questionnaire, regarding the set of questionnaires that are generated or completed; a similar case occurs with the process of carrying out the coevaluation questionnaires. Since the self-assessment is filled in by the valued individual, it has its respective weight. It is important to highlight that each type of evaluation has its respective weighting in the trifocal model; therefore, the heteroevaluation, coevaluation and self-evaluation have their weight. The partial results when completing this trifocal measurement of the indicators depend on the sum of their scaled values by their weights and the weights given to both the three types of questionnaires and the valuators or evaluators.

Therefore, the weighted values of the indicators maintain different weighted relations or connections with the different specific competences of the model; in other words, an indicator can be related to one or more specific competences; and in turn, these specific competences, like the previous case, have one or more connections with the general competences. The final result obtained in each branch of the suggested competence evaluation/valuation model depends on the sum of the evaluated results found when using the different mathematical operations.

With the information mentioned above, it is suggested that "the sum of subjectivities (qualitative measurements) enable the attainment of objectivity (quantitative measurements)."

Within the process of evaluation of competences performed by the subsystem of CREAMINKA, the skills that a person has can be qualified based on a scale. In **Figure 3**, it can be observed how a user of the system has a score for their general skills based on a scale represented by measure scale (MS); and on the right side, we present the process of how the calculation of the weighting for a general competition is performed. Starting from the right side, the assessment score (fs) are related to the indicators, considering that the scale of each fs is within the MS elements. Each of the fs scores has a weight v for the calculation of the weighting of specific SCS competences that can also take a value within the MS scale. Finally, each score of the specific competences has a weight for the calculation of the general GCS competences.

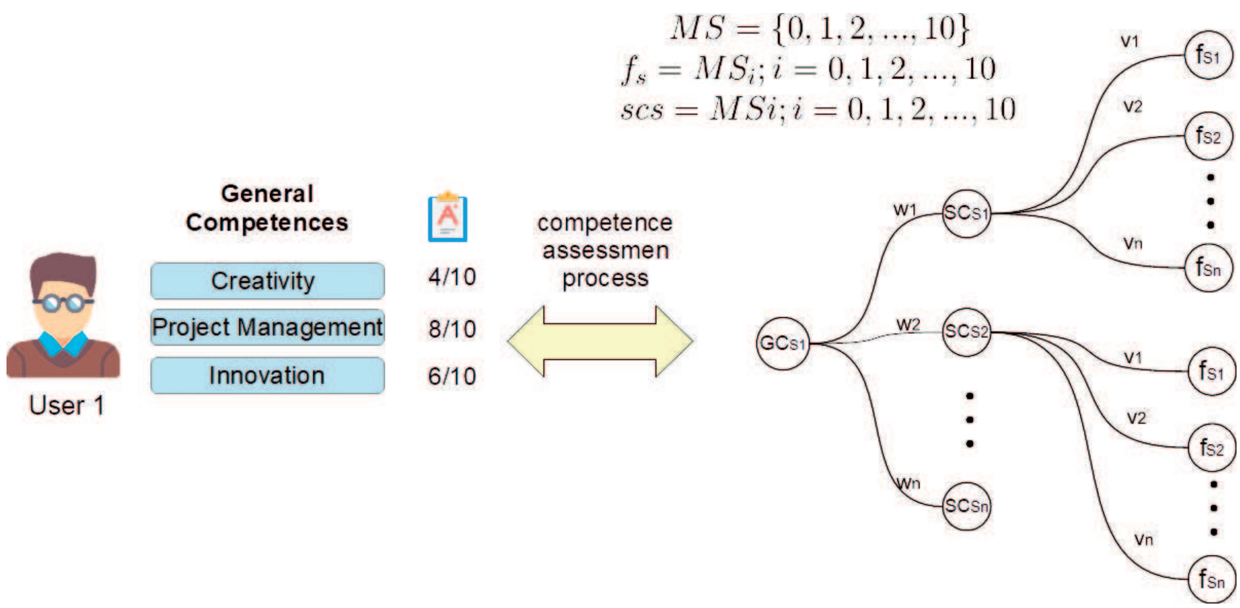

Figure 3. Evaluation process schema of general competences.

4.2. Ontology

CREAMINKA's ontology, with its CO prefix, models ecosystems immersed in scientific research and coworking. It is an ecosystem where students, teachers and external collaborators interact within different internal and external processes and events, generating different types of scientific products. In the case of this ontology, all concepts related to the coworking ecosystem will be analyzed, a module that extends the functionalities raised in the preliminary phases of CREAMINKA's ontology, where only scientific research was considered within the research groups.

Within the framework of the ontology development, it was considered to reuse ontologies such as FOAF [39], which describes various concepts related to individuals and groups; BIBO [40], which describes bibliographic information of the documents that will be generated; VIVO [41], which describes the research community model and extends some of the ontologies named above; BFO [42], which describes a high level ontology for the categorization of concepts and used very frequently in the ontologies reuse phase, when combining. In the case of the CREAMINKA ontology, concepts such as processes and generic independent entities were used to have a grouping reference framework.

4.2.1. Definition of the ontology

The discourse universe *D* as seen in Eq. (1) contains all elements of the coworking ecosystem that hold evaluation process, events, classification of knowledge, scalar measures units, projects and participation roles.

$$\begin{aligned} D = \{ & Process, Concept, Keyword, ResearchLine, Role, EvaluatorRole, \\ & EntrepreneurshipProject, Prototyping, MarketEvaluation, AssessmentProcess, \\ & Grant, Person, Group, Team, Organization, Competence, \\ & GeneralCompetence, SpecificCompetence, Evet \} \end{aligned} \quad (1)$$

The main unary relations defined in the ontology are:

- Process: indicates the entities that are occurring over time referring to a material entity.
- Keyword: represents a keyword related to a concept.
- Research line: specific investigation topic of an area.
- Role: quality of a material entity that carries a special circumstance within a context.
- Entrepreneurship project: a process that takes place over time to carry out an entrepreneurship of an idea.
- Research project: a process that occurs over time, to carry out an idea related to the research area.
- Prototyping: subprocess of a project in which a subproduct to be valued is obtained as purpose.

- Assessment process: process in which the assessment of different indicators is carried out, which has as output the scores of the indicators in relation to a scale.
- Competence: represents the abilities that a person has to develop something.
- Measurement weight: represents the weight relationship that exists between two concepts.

The main binary relationships that were modeled are described below:

- Has weight: indicates the weight relationship that exists in a class and its weight-class quantifier.
- Evaluated: indicates the evaluation process that was carried out on another process.
- Apply evaluation format: specifies the evaluation format on which the evaluation process is based.
- Score for: specifies the score that an indicator or test has.
- Has measurement unit: indicates the unit of measurement used as a reference in a score.
- Has indicator: specifies the indicator to which a concept is linked.
- Has subprocess: indicates the belonging of a process to a higher process.
- obo: participates in: defines the relationship between continuous objects and occurring objects.
- obo: barer of: specifies the relationship between a dependent entity and a dependent entity.

The set of relations R is defined as seen in Eq. (2):

$$R = \{hasWeight, evaluated, applyEvaluationFormat, scoreFor, hasMeasurementUnit, hasIndicator, hasSubProcess, participatesIn, bearerOf\} \tag{2}$$

Specification of the subconcepts of unary relationships in ontology as seen in Eq. (3):

$$O_0 = D \cup \{Process(x) \rightarrow Project(x), Project(x) \rightarrow EntreperneurshipProject(x), Project(x) \rightarrow ResearchProject(x), Process(x) \rightarrow Prototyping(x) \rightarrow Process(x) \rightarrow MarketEvaluation(x), Process(x) \rightarrow AssessmentProcess(x), AssessmentProcess(x) \rightarrow CoEvaluation(x), AssessmentProcess(x) \rightarrow HeteroEvaluation(x), AssessmentProcess(x) \rightarrow AutoEvaluation(x), Competence(x) \rightarrow SpecificCompetence(x), Competence(x) \rightarrow GeneralCompetence(x) \tag{3}$$

Specification of domains and ranges of binary relations as seen in Eq. (4):

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$$\begin{aligned}
&O_0 = O_0 \cup \{bearerOf(x, y) \rightarrow Person(x) \wedge Role(y) participatesIn(x, y) \rightarrow \\
&Roles(x) \wedge Process(y) hasWeight(x, y) \rightarrow \\
&Thing(x) \wedge WeightMeasurement(y) Evaluated(x, y) \rightarrow \\
&AssessmenteProcess(x) \wedge Process(y) applyEvaluationFormat(x, y) \rightarrow \\
&AssessmentProcess(x) \wedge Test(y) scoreFor(x, y) \rightarrow \\
&Score(x) \wedge Test(y) scoreFor(x, y) \rightarrow \\
&Score(x) \wedge Indicator(y) hasMeasurementUnit(x, y) \rightarrow \\
&Thing(x) \wedge MeasurementUnit(y) hasSubProcess(x, y) \rightarrow Process(x) \wedge \\
&Process(y)\}
\end{aligned} \tag{4}$$

4.2.2. Conceptualization of competence assessment

In order to analyze how the different concepts of the developed ontology for the CREAMINKA subsystem interact, we have to separate the several concepts associated at different levels, starting with the conceptualization of the weights that work as a complex relationship between concepts of the different levels of the competences evaluation model. Then, an analysis of how such levels are related within the evaluation model is addressed, in an evaluation process, and the actors involved. Finally, the approach is based on the analysis of how assessments take place within the different processes that normally take place within the ecosystem of a StartUPS.

Within the competence assessment model, we intend to move from a qualitative assessment to a quantitative assessment attempt, as mentioned above, whereby the concept that links the different components between levels of the model that are represented as classes is referred to as weight measurement. This is a complex concept since it works as a link entity that qualifies the relationship between two classes, giving weight to the different associated concepts as it can be observed in **Figure 4**. When analyzing the domain of the relation has weight, we discovered concepts that were implicit in the scheme of the competence evaluation model, the ontology has to consider the evaluator role within the assessment process and link it to a weight.

The “assessment process”, as seen in **Figure 5**, includes both the “person” or “persons” who have been evaluated and the evaluator, distinguishing these persons by the role they have within the process. That is how the CO ontology extends the roles raised in VIVO ontology, adding the “Assessed Entity Role” and “Evaluator Role”. Evaluator role is not directly related to assessment process, since, as we saw in the previous section, the relationship between these two concepts is complex and they have to quantify that relationship through “Weight Measurement”. This evaluation process has to evaluate a process that, within the StartUPS ecosystem, is usually an entrepreneurial project or a subprocess of it, considering the members of the project. The evaluation process must “have outputs” that in this case are "scores" of the indicators or "tests" evaluated with reference to a “measurement unit”. To classify directly if a score belongs to a partial score or total score, equivalence rules were made in the ontology since if the range that passes through the “score for” is an indicator, it is known that the entity must belong to the partial score; but if the rank entity is test, it is known that it is the total score of the test. The outputs of the evaluation process that are scalar measures have to be referenced

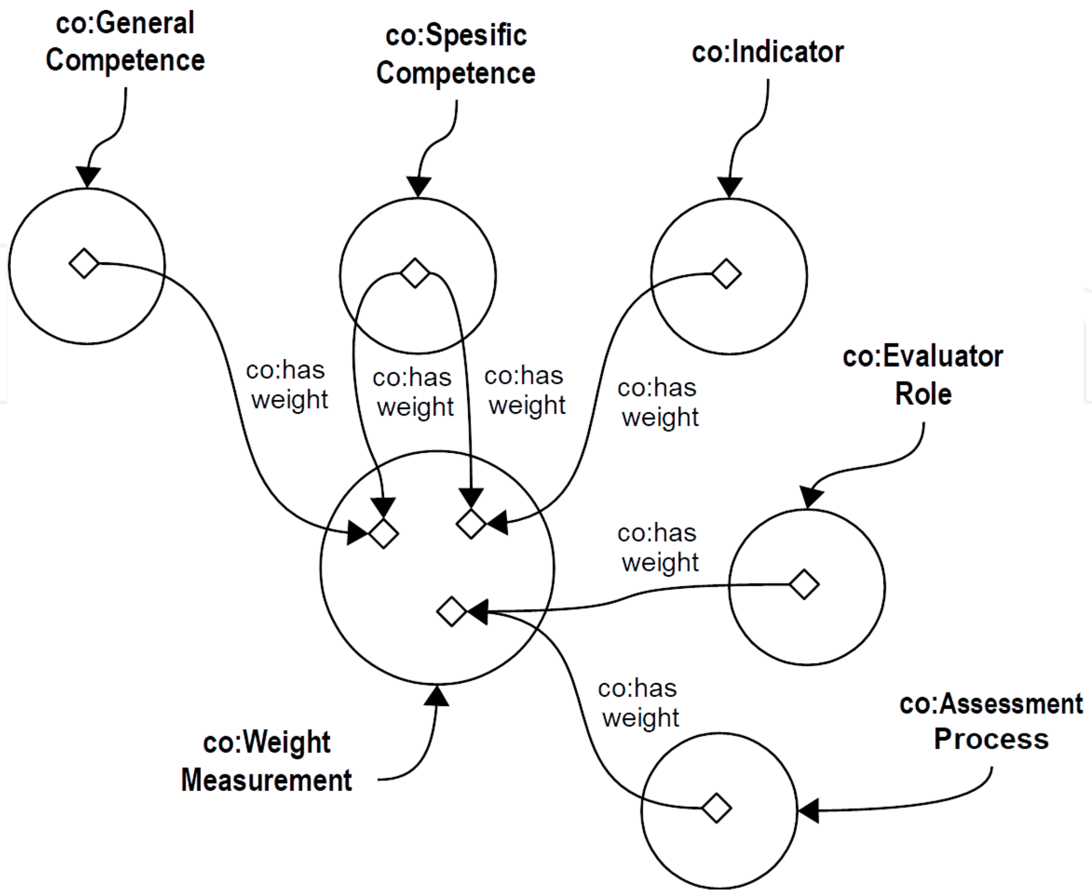

Figure 4. Conceptualization of weights at the levels of the competence assessment model.

with a scale as mentioned above; this role is fulfilled by the concept of measurement unit in which there can exist instances such as Likert scale. When performing an evaluation process, a test that links indicators through the relationship "has indicator" is always taken as reference.

Previously, we discussed about the different types of evaluations that formed trifocal evaluation/assessment. Within the CO ontology, this knowledge is inferred through the definition of axioms within the equivalences, to distinguish between three types of processes that are subclasses of assessment process, these equivalence rules are:

- Coevaluation: the person who is the bearer of an evaluator role participates in a process by means of a role and the process is evaluated by an assessment process that is linked to the evaluator role, and that person does not have a role that participates in the assessment process.
- Self-evaluation: the person who is the bearer of an evaluator role participates in a process through a role and the process is evaluated by an assessment process that is linked to the evaluator role, and that person has a role that participates in the assessment process.
- Heteroevaluation: the person who is the bearer of an evaluator role does not participate in a process through a role and the process is evaluated by an assessment process that is linked to the evaluator role, and that person does not have a role that participates in the assessment process.

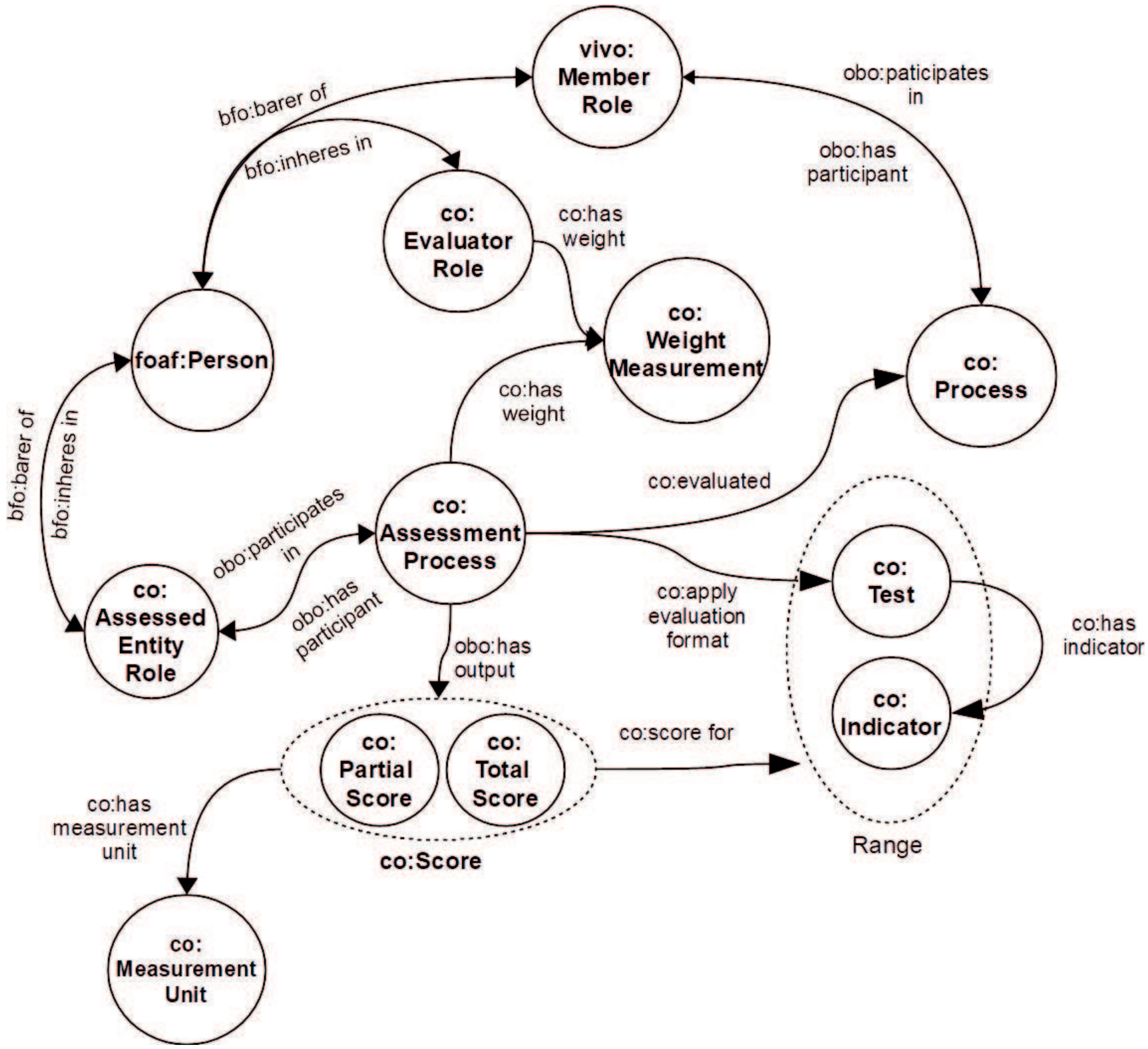

Figure 5. Schematic diagram of the competences evaluation process in the ontology.

The relationships that the evaluations have within the coworking ecosystem were modeled on the ontology and can be observed in **Figure 6**, where it can be seen how people fulfill different roles within the ecosystem through a participation relationship within events that can be the different workshops, training courses, boot camps or other instances that match the different events in which the skills acquired through assessment process are evaluated. Added to this, within the processes, we can find the entrepreneurship projects in which people fulfill a role, from these projects subprocesses like prototyping can be broken down, where the entrepreneurship project as the prototyping process can be evaluated.

As discussed in this section, each of the approaches from the relationship of weights to the different levels of the competence assessment model, the actors within the evaluation process and the relationship of the evaluation process with the different occurrences of which they are part of, the actors of the coworking ecosystem allow us to give an approximation of the competence assessment of an actor who participates in different events and entrepreneurship projects modeled on an ontology.

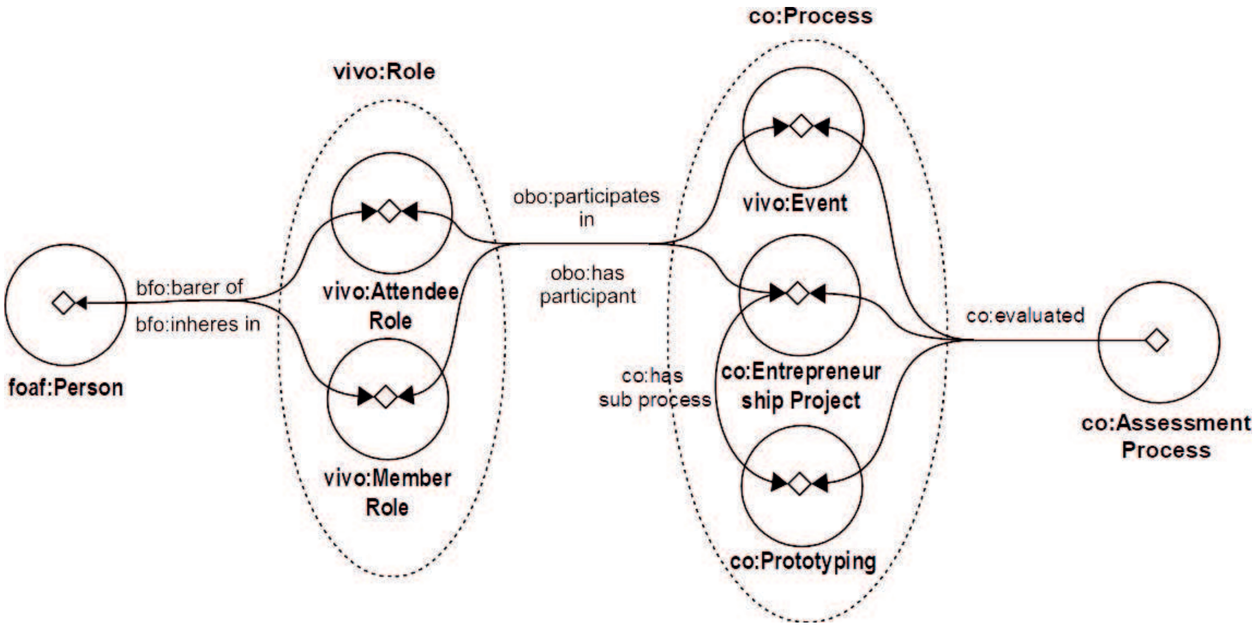

Figure 6. Schematic diagram of the evaluations of the different process performed in the coworking ecosystem in the ontology.

5. Experimentation and preliminary results

In order to check the traceability of people within the different processes that are performed in the coworking ecosystem modeled as a part of the CREAMINKA ontology, a SPARQL as shown in **Figure 7** is tested on the database where it can be observed as a result in **Table 1** the person next to the role which he participates with, in a process, such as entrepreneurship projects, boot camps and training workshops.

SPARQL consultation on actor's participation in the coworking ecosystem processes:

Obtained results:

In order to provide a tool to analyze the development of both general and specific competences of students/participants involved in entrepreneurship and/or research processes, we have designed two metrics. The first metric to determine the level of development that achieves a student/participant for a general competence as seen in Eq. (5):

$$GC_s\left(St_i, GC_j\right) = \frac{1}{\sum_{w \in \overrightarrow{W_j}} (w \cdot H1)} \sum_{k=1}^{N} w_k \cdot S\left(St_i, SC_k^j\right) \quad (5)$$

where:

- $GC_s\left(St_i, GC_j\right)$ represents the score achieved by ith-student St_i for the jth-general competence GC_j. The number of general competences is defined by the experts in higher education, entrepreneurship and research.
- $\overrightarrow{W_j}$ is a vector of weights related with the jth-general competence GC_j.

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX co: <http://www.creaminka.org#>
PREFIX vcard: <http://www.w3.org/2006/vcard/ns#>
SELECT DISTINCT  ?person ?roleClass ?titleProcess
WHERE {
    ?bearerOf rdfs:label ?labelBearerOf;
    filter(str(?labelBearerOf)="bearer of").
    ?participatesIn rdfs:label ?labelParticipatesIn;
    filter(str(?labelParticipatesIn)="participates in").
    ?person ?bearerOf  ?role.
    ?role ?participatesIn ?event;
        rdf:type ?roleClass.
    ?roleClass rdf:type owl:Class.
    ?event vcard:title ?titleEvent.
}
```

Figure 7. Query SPARQL of the traceability of a person in the coworking ecosystem.

- $H1$ represents the maximum score for each specific competence SC_k^j.
- $\frac{1}{\sum_{w\in\vec{W}_i}(w\cdot H1)}$ is a normalization factor used to scale the sum of weighted scores.
- $S(St_i, SC_k^j)$ is the score achieved by the ith-student St_i for a specific competence SC_k^j, whereas w_k is the kth-weight used to define the importance of this score. Each specific competence SC_k^j is related to the jth-general competence.
- N is the total of specific competences considered in the study.

On the other hand, the second metric allows us to know the level of development that students/participants achieve for each of the specific competences that make up a general competence. For this, the following equation is used as seen in Eq. (6):

$$S(St_i, SC_k^j) = \frac{1}{\sum_{v\in\vec{V}_j}(v\cdot H2)} \sum_{f\in\vec{F}, v\in\vec{V}_j} f\cdot v \tag{6}$$

where:

- f is the value assigned by the expert team according to the development level reached by the student/participant in this indicator.
- $H2$ represents the maximum score for each specific indicator f.

First name	Last name	Role class	Title event
Sofia	Agua	Attendee role	Boot camp 2017
Sofia	Agua	Attendee role	Training Course Artificial Intelligent
Sofia	Agua	Member role	Project SIRO
Andrés	Mena	Member role	Project SIRO

Table 1. People traceability results obtained with the execution of the SPARQL queries (coworking ecosystem).

- $\vec{V}_j$ is a vector of weights related with the *j*th-specific competence sc_k^j.
- $\vec{F}_j$ is a vector that contains all the indicators related with the *j*th-specific competence sc_k^j.

On this basis, we have used the metrics described above to create a module that allows performing clustering analysis. This module allows system users testing different values of weights as well as generating dendrograms and cluster graphics. This information is useful in decision-making for managers and research/entrepreneurship group directors.

In **Figure 8**, we can see an example of a dendrogram generated by the system from the specific competences and indicators retrieved from 20 participants in entrepreneurship projects,

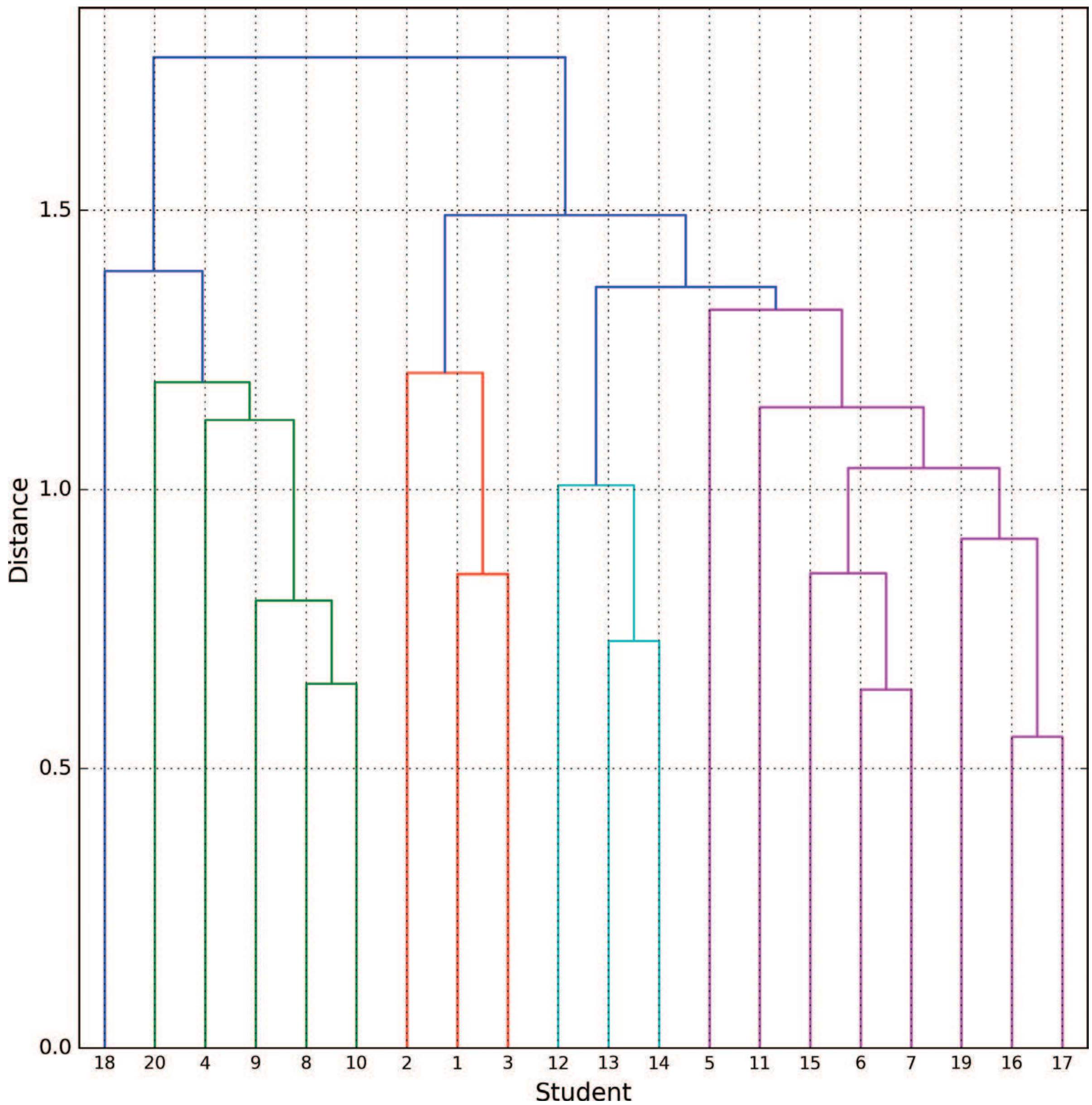

Figure 8. Dendrogram that is generated from the analysis of indicators of the participants and students of research and entrepreneurship groups.

http://dx.doi.org/10.5772/intechopen.73212

boot camps and training workshops. The information feed to the clustering analysis module is described below:

- Three general competences for each participant ("*creativity,*" "*project management,*" "*entrepreneurship and innovation*").
- Nine specific competences per participant considering the following number of indicators (for each competence): $\vec{f} = \{3, 3, 3, 4, 4, 3, 3, 3, 2\}$. The specific competences consider aspects such as "*Design a work project without reaching its execution,*" "*Find and propose new procedures and solutions to a given problem with forward thinking and leadership attitudes,*" etc.

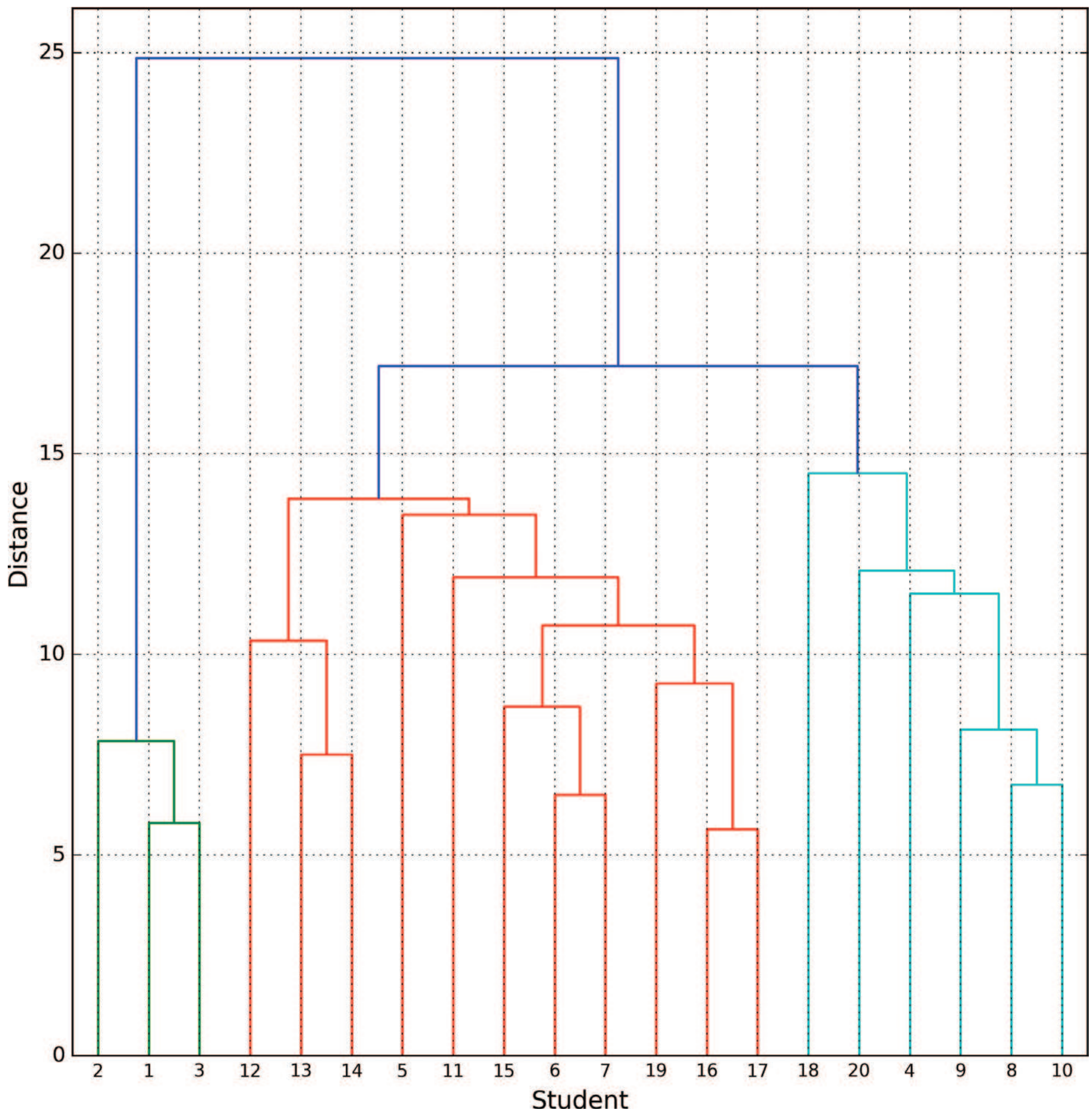

Figure 9. Dendrogram that is generated from the analysis of indicators of the participants and students of research and entrepreneurship groups.

- The participants are enrolled in different careers such as systems engineering, electrical engineering, business administration, etc.

As shown in **Figure 8**, if we cut the dendrogram at a distance of 1.33, four groups are formed. For example, with this information, we can observe that participants 8 and 10 have a similar profile in general in their specific competences, although they are from different careers (social communication and mechanical engineering).

On the other hand, in **Figure 9**, we can observe how new groups are formed when the specific competences are considered. As we can see, there are three perfectly defined groups where you can establish leadership, vision, entrepreneurship, etc. characteristics.

6. Conclusions

We present a set of knowledge that describes the coworking ecosystem in which several actors participate in various processes that pretend to generate competences in the participants; in that way, it is possible to give a traceability of how an actor gets involved through different roles in the coworking ecosystem, as described in the results phase; and it is even more important, the fact that each of the competences at different levels is developed, and at the same time, they are being evaluated within the processes in which the actors participate. This assessment within the set of knowledge of the ontology allowed to link the concepts of competences and the processes that form these competences in the actors. This link includes the trifocal valuation approach with weights in each of the arcs that join the concepts. This whole set of knowledge was built by reusing ontologies with different approaches in the research, extending some of the concepts to adapt them to the needs of the ecosystem that was searched to model.

On the other hand, it is important to mention that the development of competences by students/participants of entrepreneurship or research groups is an area that has not been adequately addressed at the present time. However, this area is very important in any organization conducting research and/or entrepreneurship processes, given that the participant human talent should develop competences which can substantially enrich the performance and production of knowledge.

As lines of future work, we propose the following:

- To develop a deep learning approach to suggest reinforcement strategies to develop some specific competences related with leadership training.
- To develop an intelligent module that allows combining profiles of students and participants in work groups focused on solving problems that require different types of skills (both general and specific).

http://dx.doi.org/10.5772/intechopen.73212

Author details

Juan Pablo Salgado Guerreo[1], Daniel Pulla Sánchez[2], Jorge Galán Mena[2],
Vladimir Robles Bykbaev[2]*, Verónica Cevallos León Wong[2] and Adrián Narváez-Pacheco[3]

*Address all correspondence to: vrobles@ups.edu.ec

1 Vicerrectorado de Investigación, Universidad Politécnica Salesiana, Cuenca, Ecuador

2 Grupo de Investigación en Inteligencia Artificial y Tecnologías de Asistencia, Universidad Politécnica Salesiana, Cuenca, Ecuador

3 Departamento de Tecnologías de la Información, Universidad Politécnica Salesiana, Cuenca, Ecuador

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